E **Appendix E: Nonpoint Source Nutrient Loading Assessments**

For watershed planning purposes it is reasonable to estimate average annual nutrient nonpoint source (NPS) loads using the EPA Chesapeake Bay Program (CBP) loading coefficients. The CBP peer review process ensures that these values receive regular technical scrutiny. Although it is acknowledged that these average values are not site-specific, they provide reasonable, defensible loading rates for which refinements may be proposed in the future. In addition, the use of CBP loading coefficients promotes consistency with the Tributary Strategies under the Chesapeake Bay Agreement 2000 (C2K).

The following technical guidance describes how to obtain CBP NPS loading information and several ways the information can be used to conduct NPS loading assessments. Examples of regionally specific nonpoint source loading information available from the Bay Program web site include the following (all are long-term average annual loads):

A) Most-current NPS nutrient loading rates by land use category.
B) Future NPS nutrient loading rates by landuse category that account for full Tributary Strategy implementation.
C) 1985 period when few BMPs had been implemented.
D) 100% forested landscape.
E) No BMP implementation.
F) Implementation of every BMP, implemented by everyone, everywhere (E3).

The information above can be used to conduct the following NPS loading analyses, several of which are explained in more detail later in this appendix:

- Current Load: What is the current average annual nutrient load from a particular watershed? Use the estimated loading rates from (A) and the land use in the particular watershed to estimate the current loads.

- Future Land Use Load: What is the expected future average annual nutrient load from a particular watershed accounting for projected land use change? Use the estimated loading rates from (A) and future land use in the particular watershed to estimate the future loads.

- Load Reduction Needed: What NPS nutrient load reduction is needed to reach the TMDL NPS allocation in a particular watershed? The analysis can account for current land use (i) or future land use (ii). Use most current estimated load from (A), and the TMDL NPS allocation as follows:

  (i) TMDL NPS Allocation – Current Load = NPS Reduction Needed
  (ii) TMDL NPS Allocation – Future Land Use Load = NPS Reduction Needed

- Lowest Practicable NPS Load: What is the lowest NPS load that can be reasonably expected from the current land cover? Use either the E3 loading in (F) or the Tributary Strategy loading in (B) and land cover data for the particular watershed to estimate the lowest viable

NPS load using conventional BMPs. The analysis can account for current land use or future land use.

- Greatest Practicable NPS Reduction: What is the maximum possible NPS load reduction that could be achieved relative to the current loading using conventional BMPs on the current landscape? The analysis can account for current land use or future land use. Subtract the Tributary Strategy NPS load for the current land cover computed using (B) from the current load using (A).

  Current Load – Tributary Strategy Load = Greatest Practicable NPS Reduction

  Greater reductions could be achieved if land cover is changed by reforestation and wetland restoration initiatives, phosphorus-free fertilizers are adopted, or other social changes are accepted.

- What is the change in NPS loading due to replacing 100 acres of forestland with developed land that accounts for required stormwater management? What's the change in NPS loading due to replacing 75 acres of cropland and 25 acres of forestland with developed land? These analyses can account for development on sewer or septic systems.

Note that none of the analyses above require an inventory of best management practices (BMPs), although these Bay Model loading rates account for BMPs that have been implemented. Note also that some of the annual per-acre loading rates represent spatial averages. For example, the current urban loading rate represents the average of areas with stormwater BMPs and areas without stormwater BMPs, similarly for agricultural loading rates.

CASE 1: Estimating Current NPS Nutrient Loads

Each year the Chesapeake Bay Program (CBP) updates the estimated average annual loads by region by accounting for new pollutant sources and the implementation of nutrient controls (BMPs)[25]. Estimating the current load entails the following steps for total nitrogen and total phosphorus:

- Download a spreadsheet file with the most current Bay Program loads for the region of interest (a Bay model watershed segment. See detailed instructions below).
- Open the spreadsheet and calculate the loading rates for each land use by dividing the load by the acres.
- Obtain the most current land use in the watershed of interest. It might be necessary to aggregate detailed land use types into a fewer number shown in Table 1 below.

[25] The most recent estimation is usually about one-year old, because it takes time to inventory BMP implementation progress and then run the Bay Watershed Model to estimate the loading rates. It should also be understood that the "current" NPS load estimate represents a ten-year rainfall period on land that mimics the land cover and BMP implementation for the year of interest. Thus, it is a long-term average intended to average over wet and dry years. This enables comparisons of loads between years due to changes in BMPs and not due to differences in rainfall

- Create a spreadsheet with columns for A) land use type and open water for cases in which there are large waterbodies, B) acres, C) loading rates (lbs/yr/ac), and D) the load for each land use, which is the product of each land use acreage (B) and loading rate (C).
- Sum the entries in column D to obtain the total current NPS load.

CASE 3, below, provides more discussion of the current load, and Table 3 provides an example of the spreadsheet mentioned above. The section entitled "Data Download Process," explains how to obtain the data from the Bay Program web site, and includes procedure for separating the septic contribution from the urban stormwater contribution.

Table 1 shows the 2003 estimated loading rates for two watersheds. This provides an example of relatively "current" loads, showing that the loading rates differ slightly by region. Note that the urban loading rate includes septic systems.

Table 1

2003 Estimated Average Annual Loading Rates of Total Nitrogen

Major Land Use	Potomac River Segment 210	Lower Eastern Shore Segment 430
	lbs/acre/year	lbs/acre/year
AGRICULTURE	16.2	16.0
ATDEP WATER	10.4	9.6
FOREST	2.0	1.2
MIXED OPEN	6.3	4.4
URBAN*	18.9	15.1
* Includes Septic Contributions		

CASE2: Estimating the Lowest NPS Load that can be Achieved with Conventional BMPs on the Current Land Cover: The "E3" or Tributary Strategy Loads.

In 2002, the Chesapeake Bay Program estimated a credible minimum technically feasible load by simulating what would occur if "everyone, does everything, everywhere" to reduce nutrients. Unit area loading coefficients for this scenario, called "E3" for short, are available in a spreadsheet from the Chesapeake Bay Program website. See Excel file "detailed loads and landuse acreage" under Section "Chesapeake Bay Program Watershed Model Output Data." http://www.chesapeakebay.net/tribtools.htm

It is universally accepted that the implementation of every conceivable BMP assumed in the E3 scenario is not practical. As a more practical estimate of the lowest NPS load, Maryland's Tributary Strategy could be used. These loads are also considered extremely ambitious.

These estimates can be enhanced in several simple ways. First, the land cover can be modified, for example, to simulate a reforestation initiative. Second, loading rates can be mixed from two or more sets of coefficients. For example, if the septic load reductions in the Tributary Strategies seem too ambitious, the septic loads from the "current" scenario can be used in combination with the remaining coefficients from the "Trib Strategy" scenario.

CASE 3: Estimating the Maximum Feasible NPS Nutrient Reduction Potential with Conventional BMPs on the Current Land Cover: Current Load – Tributary Strategy Load

Note: The analyses described below could be performed using the E3 loading rates discussed in CASE 2.

The "NPS nutrient reduction potential" for a watershed is the estimated amount of NPS load that could be reduced relative to the current load. This can be computed as the difference between the current NPS load, and the NPS load that would result if Maryland's Tributary Strategy is fully implemented.

Table 2 provides a sample computation of the NPS nutrient reduction potential for a watershed with hypothetical acreages using the loading rates associated with the Lower Eastern Shore region (CBP watershed segment 430).

As of April 2005, the CBP's most recent estimate of the "current" NPS load was for 2003. The total watershed NPS load is computed as the sum of the loading contributions from each land use. For example, the agricultural load is computed as Column B multiplied by Column C (7,345 x 16 = 117,520). Summing all of the cells in Column D yields the total 2003 NPS load of 139,874 lbs/year.

Again, be aware that this is not an estimate of the NPS load generated in 2003. Rather, it is an estimate of the *long-term average annual load*, accounting for variations in annual rainfall over ten years, and conditions on the ground in 2003. This procedure allows comparisons between years due solely to changes in BMPs and not due to differences in rainfall for a given year.

The Tributary Strategy load is computed in a way similar to that for the 2003 load, using revised loading rates in Column E, rather than the rates in Column C. For example, the reduced agricultural load is estimated to be 9 x 7,345 = 66,105 lbs/year. The total long-term average annual load predicted when the Tributary Strategy is fully implemented is about 82,164 lbs/year.

Thus, the maximum NPS reduction potential for this hypothetical watershed, assuming no land use changes occur, is 139,874 lbs/year – 82,164 lbs/year = 57,710 lbs/year. This implies a 41% NPS reduction potential is possible. If an analysis indicates that greater reductions than this are needed, then more detailed analyses and discussions with MDE staff are warranted.

Refined Land Use Categories

If sufficient data is available, the CBP's refined land cover categories may be used to estimate nutrient loads in a manner analogous to those examples described above, only with more detailed land use categories. It is also possible to use subsets of the following land categories, for example, using more refined urban information, and less refined categories for the other land uses. Table 3 shows refined land use categories (left column) and their corresponding major land use categories (right column), as defined by the CBP.

Table 2

A	B	C	D	E	F
Major Land Use	**Land Area**	**"Current" 2003 Loading Rates**	**"Current" 2003 Annual Loads**	**Trib Strategy Loading Rates**	**Trib Strategy Annual Loads**
	acres	**lbs/acre/year**	**lbs/year**	**lbs/acre/year**	**lbs/year**
AGRICULTURE	7,345	16.0	117,520	9.0	66,105
ATDEP WATER	35	9.6	366	7.9	278
FOREST	4,544	1.2	5,453	1.2	5,300
MIXED OPEN	320	4.4	1,408	3.3	1,062
URBAN*	1,002	15.1	15,130	9.4	9,419
TOTAL	11,246		139,847		82,164
* Includes Septic Contributions					

Table 3

Chesapeake Bay Program Watershed Model Land Uses and Major Land Use Categories

LAND_USE	MAJOR_LAND_USE
Forest	FOREST
High Till (Crop)	AGRICULTURE
Low Till (Crop)	AGRICULTURE
Pasture	AGRICULTURE
Perv Urban	URBAN
Hay	AGRICULTURE
Mixed Open	MIXED OPEN
Imp Urban	URBAN
Manure	AGRICULTURE
AtDep Water	ATDEP WATER
Septic	URBAN

See land use descriptions on page 6 below

Loading rates, like those examples in Table 1, are also available for the more detailed land use categories shown in the left column of Table 3. These can be obtained from the CBP web site by selecting "All Land Uses" in Step 2 D of the data download process described below.

The Chesapeake Bay Program land uses are described below.

Atmospheric Deposition to Water (AtDep Water) simulates atmospheric deposition loads directly to the rivers, lakes, reservoirs, and streams of the watershed.

Forest contains both forested and wetland land covers.

Hay, **Pasture**, **High Tillage** (High Till), and **Low Tillage** (Low Till) are defined as cropland with varying applications of nutrient input and management practices.

Manure land use represents concentrated manure piles on agricultural land. [It is advised that this be used in consultation with the Bay Program staff].

Point source and **septic** land uses load directly to the tributary waters.

Pervious urban (perv urban) and **impervious urban** (imp urban) represent non-point source urban loads.

Mixed Open represents land that is not specifically urban or agricultural and may include parks, golf courses, large residential lots, and school yards.

The application of the CBP's more detailed land use loading coefficients necessitates an estimate of pervious and impervious urban land use. Table 4, from the TR-55 Manual for modeling urban hydrology for small watersheds, may be used to develop estimates. It should be noted that these estimates do not account for reductions in "effective imperviousness" associated with implementation of Maryland's stormwater management law on development after 1985, and the retrofitting of older development.

Table 4
Percentages of Average Impervious Area

Land Cover Type	Percentage of Impervious Area
Urban Districts	
Commercial	85
Industrial	72
Residential Districts by Ave Lot Size	
1/8 acre or less (town houses)	65
1/4 acre	38
1/3 acre	30
1/2 acre	25

1 acre	20
2 acres	12

Data Download Process

Option 1: A large spreadsheet of all loading rates for all scenarios and watershed segments is available from the Bay Program. See Excell file "detailed loads and landuse acreage" under Section "Chesapeake Bay Program Watershed Model Output Data." These loading rates are for land use categories shown in the left column of Table 3.

http://www.chesapeakebay.net/tribtools.htm

Option 2: Subsets of the large spreadsheet in Option 1 can be downloaded individually. This option provides loading rates by both land use categories in Table 3 (left column or right column). Unfortunately, this option does not include all scenarios, e.g., does not include the E3 scenario.

The following process describes how to obtain similar loading rates by geographic region.

Step 1: Determine the Applicable Watershed Segment: To obtain loading information for a particular region, begin by determining which watershed CBP model segment corresponds you your particular case. A watershed segment map is available via the internet at: http://www.chesapeakebay.net/pubs/maps/2002-134.pdf

For the far western part of Maryland use Segment 160. For the Coastal Bays region, use Segment 430. If it is difficult to determine which segment corresponds to your region, use your best judgment, because regional differences are not that drastic, or contact the CBP Office for assistance at 800-YOUR-BAY ext. 844.

Step 2: Download Nutrient Loading Data: The following information should support a reasonable estimate of the baseline load (or range of loads), assuming few or no BMPs. This can be done as follows:

A. Access the "CBP Data Hub" via the internet:
http://www.chesapeakebay.net/datahub.htm
B. "Click to Get Data" on the oval in the center of the web page.
C. Click "Query Data"
The first time you do this, you'll need to register as a new user.
D. On the next web page, Select "Summary Data," Select "Major Land Uses" and Select "Watershed Segment."
E. On the next web page, scroll down to select the desired watershed segment number, which you should have determined in Step 1 above.
- Then, scroll down to find the desired scenario. If you have questions about the different scenarios, contact the CBP Office for assistance at 800-YOUR-BAY ext. 846.

- Then, select all of the major land uses by placing your cursor on the top land use (agriculture), holding your shift key down, and selecting the remaining land uses so that they are all shaded.
- Finally, select the "edge of stream" load type (the "delivered load" accounts for transport losses of nutrients as they are conveyed to the Bay).

F. Click on "Run Query" then Click on "Download Data." A dialogue box will appear. Select "Save," which will allow you to select the directory on your computer and file name you wish to give the data file. This text file can be read by Excel spreadsheet software, and saved in a spreadsheet format.

G. Septic Loads can be disaggregated from the urban load:

- First, run another query as in Step 2 D above, but selecting "All Land Uses" this time. You will need only one number from this spreadsheet, the total nitrogen value for septic systems. (See Step 3 "Spreadsheet Computations" below for how to use this value in obtaining the urban load without septic component).

Step 3: Spreadsheet Computations

To calculate the unit loading rate (lbs/acre/year) from each type of land use type, using the "Major Land Uses" spreadsheet, insert new columns to the right of "TN" and "TP" columns (Total Nitrogen & Total Phosphorus). Then, for each land use, divide the total load by the acres.

For example, for nitrogen on the Lower Eastern Shore (Seg 430), you would insert the column labeled (4) and divide the contents of column 3 (210,837 lbs/yr) by column 2 (13,934 acres) to arrive at 15.1 lbs/acre/yr.

Table 5

1	2	3	4
MAJOR_LAND_USE	ACRES	TN (LBS/YR)	TN lbs/ac/yr
URBAN*	13,934	210,837	15.1

* Includes the septic load component.

To determine the urban load *without* the septic load component, first obtain the septic load as described above in Step 2 G. In this particular case, the septic load is 107,004 lbs/yr. The urban load without septic component is computed as follows:

(urban load with septic – septic load)/(acres of urban land) =

(210,837 – 107,004)/13,934 = 7.45 lbs/acre/year (Urban load without septic part)

BMP-Based Accounting of NPS Loads

A more advanced way of estimating NPS loads, and developing NPS reduction strategies, is to track the available opportunities for BMP implementation and an inventory of BMPs that have been implemented. This is being done on a coarse geographic scale for the Chesapeake Bay

Agreement, which supports TMDL implementation in a general way. Doing this on a more refined scale is the eventual goal of TMDL implementation. The specific policies and procedures for doing this in a routine way are presently under consideration. Although this approach is beyond the scope of this Guidance, the concepts are outlined below.

First, compute the baseline NPS load with no BMPs. Loading rates from the 1985 CBP scenario could be used for this. Then apply reduction efficiencies associated with the desired level of BMP implementation. This can be combined with BMP cost information to assess cost-effectiveness (See Appendix I "BMP Efficiencies and Costs"). Note that when multiple BMPs are applied to the same pieced of land, the efficiencies cannot simply be added (e.g., a 55% reduction on top of a 55% reduction doesn't result in a 110% reduction).

Various database and spreadsheet tools have been developed to assist in this type of analysis (See Load Estimations under Section 5.2.1). Several State agencies are presently working with on the development of a GIS-based tool that will be considered for use in TMDL implementation planning and decision-making.